Fisheries and Oceans Canada | Pêches et Océans Canada
Ecosystems and Oceans Science | Sciences des écosystèmes et des océans
Maritimes Region
Canadian Science Advisory Secretariat
Science Response 2016/029

STOCK STATUS UPDATE OF ATLANTIC SALMON IN SALMON FISHING AREAS (SFAs) 19-21 AND 23

Context

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) identified four large groups of Atlantic Salmon (*Salmo salar*), referred to as Designatable Units (DUs), in the Maritimes Region: Eastern Cape Breton (ECB, corresponding to Salmon Fishing Area (SFA) 19), Nova Scotia Southern Upland (SU, SFAs 20, 21 and part of 22), Outer Bay of Fundy (OBoF, corresponding to the western part of SFA 23), and Inner Bay of Fundy (IBoF, part of SFAs 22 and 23) (see Appendix).

Abundance of Atlantic Salmon in the Maritimes Region has been in decline for more than two decades. Populations in many rivers are extirpated and IBoF salmon are listed as Endangered under the Species at Risk Act (SARA). In November 2010, COSEWIC assessed the ECB, SU and OBoF population assemblages as Endangered. Fisheries and Oceans Canada (DFO) is currently undergoing the process of developing a SARA listing recommendation for these DUs. Scientific Recovery Potential Assessments, Socio-Economic Analyses, and public consultations have been completed and DFO is in the process of developing Regional listing recommendations for the Minister.

Science advice on the status of Atlantic Salmon in SFAs 19-21 and 23 for 2015 was requested by Fisheries and Aquaculture Management. This advice is used to inform Aboriginal communities, clients, and the provinces of Nova Scotia and New Brunswick of the status of the salmon resource in advance of developing harvest agreements and recreational fishing plans for 2016. The objectives of the request were to assess the status of Atlantic Salmon stocks in SFAs 19, 20, 21 and 23 up to the end of 2015 using the following indicators:

- adult abundance relative to reference levels;
- juveniles densities; and
- smolt production estimates.

Given that this request is for an update of previous advice using established methods (DFO 2014 and 2015), it was decided to use the Science Response Process.

This Science Response Report results from the Science Response Process of March 8, 2016, on the Stock Status Update of Atlantic Salmon in Salmon Fishing Areas (SFAs) 19-21 and 23.

Analysis and Response

Methods

Evaluation of the status of Atlantic Salmon in the Maritimes Region is based on abundance monitoring for a number of index populations. For most index populations, status is evaluated using a comparison of the estimated egg deposition (calculated from the estimated abundance and biological characteristics of salmon stocks) relative to a reference point known as the

conservation egg requirement. The river-specific conservation egg requirement is based on an egg deposition of 2.4 eggs/m^2 multiplied by the amount of accessible fluvial rearing habitat that is of suitable gradient. An egg deposition of 2.4 eggs/m^2 is considered to be a Limit Reference Point in the context of DFO's Precautionary Approach Framework (DFO 2009, DFO 2012, Gibson and Claytor 2012) for DFO's Maritimes Region. Conservation requirements for many of the rivers in the Maritimes Region are reported in O'Connell et al. (1997).

In this report, juvenile salmon abundance determined from electrofishing surveys is compared to Elson's norm values of 29 fry/100 m^2 and 38 parr/100 m^2 (Elson 1967). A smolt prodution estimate of 3.8 smolt/100 m^2 (Symons 1979) is sometimes used as a general reference value for rivers at or near the egg conservation requirement, and is provided here to allow for a comparison of smolt production estimates.

Eastern Cape Breton (SFA 19)

Salmon population monitoring by DFO in ECB is currently focused on three river systems: the Middle, Baddeck, and North rivers (Table 1). Parks Canada has monitored adult salmon abundance on Clyburn Brook using dive surveys similar to those conducted by DFO; however, they did not conduct this survey in 2015. The Unama'ki Institute of Natural Resources (UINR) began monitoring smolts on Middle River in 2011, and smolt population estimates are available for 2013-2015 (Table 2). Details on the assessment methods for ECB salmon populations are provided in Levy and Gibson (2014), DFO (2013), Gibson and Bowlby (2009), and Robichaud-LeBlanc and Amiro (2004).

In 2015, all rivers within SFA 19 with the exception of the Middle, Baddeck, and North rivers were closed to salmon fishing all year. The Middle and Baddeck rivers were open to catch-and-release angling from October 1st to October 31st and the North River (downstream from the area known as "The Benches") was open to catch-and-release angling from June 1st to July 15th and September 1st to October 31st (Table 1). In 2015, the reach of North River between "The Benches" and the Little Falls pool was closed to angling of any species from July 15th to August 31st. A Provincial stocking program exists on the Middle and Baddeck rivers, which aims to numerically offset anticipated catch and release mortalities on these rivers (DFO 2010). Food, Social and Ceremonial (FSC) allocations were available to First Nations on these three rivers in 2015; however, reports indicate that there were no harvests from these rivers.

In 2015, all index populations in eastern Cape Breton were assessed to be below conservation egg requirements (Table 1), with estimated values of 28, 29, and 80 percent of the requirements for the Middle, Baddeck and North rivers respectively. Smolt abundance estimates for Middle River ranged from 11,103 in 2013 to 24,110 in 2015 (Table 2). The corresponding smolt production estimates are below the reference value of 3.8 smolts/100 m^2 (Symons 1979), although the estimate was closer to this reference value in 2015 (3.10 smolts/100 m^2). A summary of the 2015 assessment results is provided in Tables 1 and 2 and a time series showing the status of adult salmon populations for the Middle and Baddeck rivers, and North River are provided in Figures 1 and 2.

Table 1. Atlantic Salmon assessment information for index rivers in SFA 19 during 2015, including catch-and-release angling seasons, conservation egg requirements, preliminary recreational catch and effort estimates, catch and release mortality estimates, dive count results, escapement estimates, percent conservation egg requirement attained, and Provincial stocking information.

	Middle River	Baddeck River	North River
2015 Angling Season	October 1st - 31st	October 1st – 31st	June 1st - July 15st and September 1st - October 31st
Assessment Information	Recreational Catch Estimates Dive Counts Mark Recapture Data (historical) Electrofishing Data (historical) Smolt Estimate	Recreational Catch Estimates Dive Counts Mark Recapture Data (historical) Electrofishing Data (historical)	Recreational Catch Estimates Dive Counts Mark Recapture Data
Conservation Egg Requirement (millions of eggs)	2.07	2.01	0.92
Preliminary Recreational Catch Estimates:*			
Small Salmon	9	12	8
Large Salmon	28	24	38
Effort (rod-days)	189	140	169
Total Catch and Release Mortality Estimates**	2	2	2
Dive Counts:***			
Small Salmon	31	17	36[a], 25[b]
Large Salmon	119	78	89[a], 77[b]
Marks / Recaptures	NA	NA	28[a, b] / 17[a], 10[b]
Estimated Escapement:***			
Small Salmon	35	32	63
Large Salmon	162	109	173
% Conservation Egg Requirement (Bayesian 90% credible interval)	**28 (21-37)**	**29 (21-39)**	**80**
Provincial Stocking:			
Broodstock Collections	5 large, 3 small (October)	5 large, 2 small (October)	NA
Juvenile Releases	~15,000 fin clipped 0+ parr (November)	~23,700 fin clipped 0+ parr (December)	NA

Table Notes:
NA = Not Applicable
*Salmo-NS Database queried on February 22, 2016. River specific mean scaling factors for small salmon, large salmon, and effort were used to estimate catch and effort in 2015 (see Sources of Uncertainty).
**An assumed 4% mortality rate is applied to estimate catch-and-release mortalities (DFO 2013).
***For North River, escapement was estimated using an average of two dive counts conducted on October 8 (a) and 27 (b), the mean observation rate for dive counts on the North River (1994-98, 2013, and 2015), and the proportion of large and small salmon observed during each respective survey in 2015. The counts for small and large salmon reported in the table include marked and unmarked fish. A pool count of salmon returns was also conducted on North River during August 19-20 where a total of 18 small and 85 large salmon were counted.

Table 2. Estimates of wild and hatchery Atlantic Salmon smolt abundance, production per unit area of habitat (smolts/100 m^2), and one-sea-winter (1SW) and two-sea-winter (2SW) return rates for Middle River.

Year	Smolt Estimate*	95% Confidence Interval	Production Per Unit Area (smolts/100 m^2)	Return Rate (%)	
				1SW	2SW**
2013	11,103	6,848 - 15,359	1.43	0.19	1.36
2014* **	11,907	2,471 - 21,343	1.53	0.33	NA
2015	24,110	12,057 - 36,164	3.10	NA	NA

Table Notes:
NA = Not Applicable
*Source: Smolt estimates provided by UINR. The smolt population was estimated using the Adjusted Peterson Estimate (Ricker 1975). All salmon >10.0 cm, not clearly resembling parr, were assumed to be smolts (see Sources of Uncertainty).
**Ninety percent of large salmon were assumed to be maiden 2SW salmon based on the aging of scale samples collected from adult salmon on Middle River during 1995–1998, 2003, and 2004.
***The number of recaptures was low in 2014 (i.e., only 4 recaptures) resulting in greater uncertainty associated with this estimate.

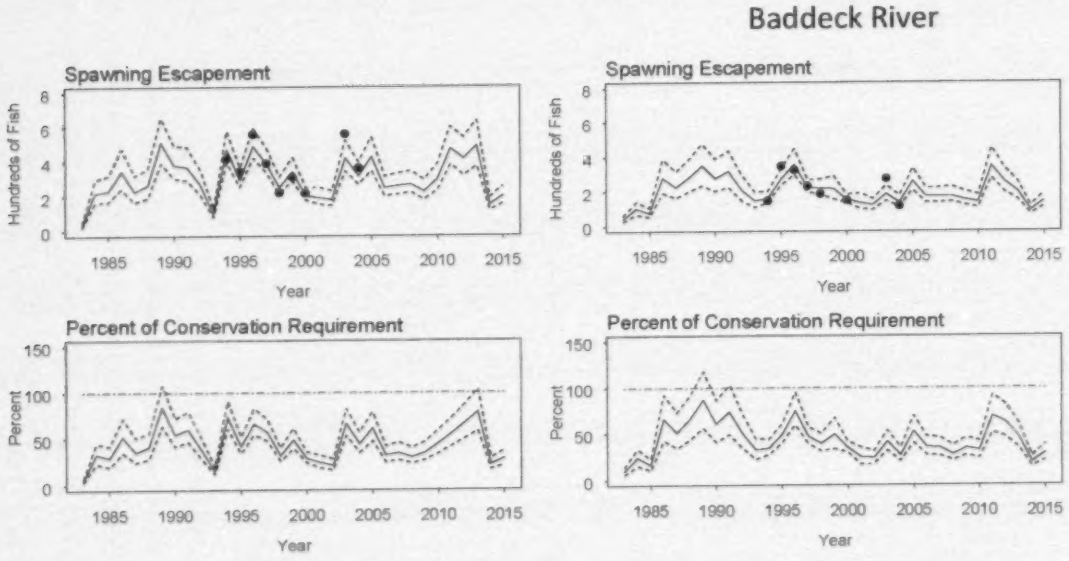


Figure 1. Estimated total number of spawners (top graph) and the percent of the conservation egg requirement attained (bottom graph) for Middle River (left panel) and Baddeck River (right panel), NS, from 1983 to 2015. Model fits derived from two methods are shown. The solid lines show the maximum likelihood estimates of annual abundance. The dashed lines show the Bayesian 90% credible interval for the annual abundance estimates. The points in the top graphs are the population estimates obtained by mark recapture during the dive surveys. The horizontal dashed line in the bottom graphs indicates 100% of the conservation egg requirement for each river.

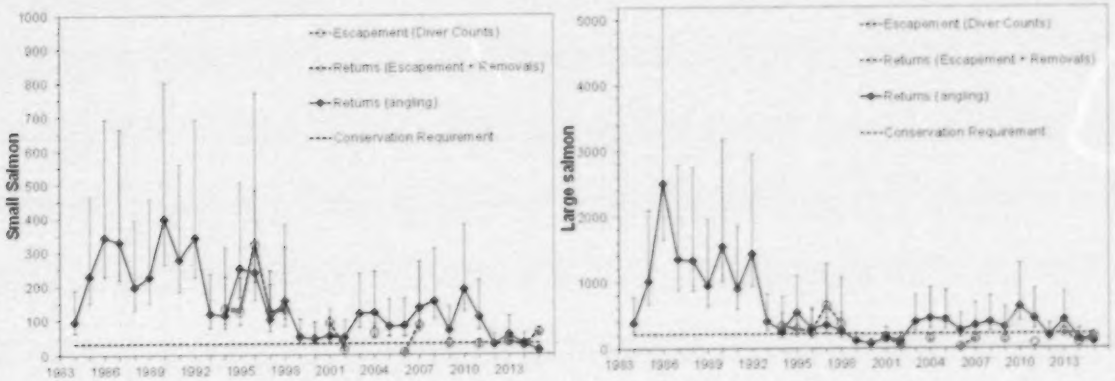


Figure 2. Estimates of the number of salmon returning to spawn and the spawning escapement for small and large salmon in North River, NS as derived from dive survey counts and from recreational catch data. The expected number of small or large salmon necessary to meet the egg conservation requirement is shown by the horizontal dashed line. Error bars represent 90% confidence intervals.

Southern Upland of Nova Scotia (SFAs 20, 21 and Part of SFA 22)

Atlantic Salmon assessment activities in the SU region are currently focused on two populations: the St. Mary's River, the index population for SFA 20, and the LaHave River, the index population for SFA 21. Beginning in 2010, all rivers within SFA 20 and SFA 21 were closed to recreational fishing for Atlantic Salmon and there were no FSC allocations. Details on the assessment methods for SU salmon populations are provided in DFO (2013) and Gibson et al. (2009).

In 2015, the LaHave River salmon population above Morgan Falls remained below the conservation egg requirement with an estimated egg deposition of 7% of the requirement. Fry and total parr (age one and older) densities (Table 3) on the St. Mary's and LaHave rivers were also low and remain well below Elson's norm values, and fry densities on the LaHave River were particularly low (0.8 fry/100 m^2). The smolt production estimate for the LaHave River in 2015 (Table 4) was less than 0.3 smolts/100 m^2 of productive habitat, which is very low in comparison to the reference value of 3.8 smolts/100 m^2 (Symons 1979). Smolt to adult return rates (a proxy for marine survival) for 1SW salmon on the LaHave River have declined to values less than 1% for the 2013 and 2014 smolt cohorts (Table 4). A summary of the 2015 assessment results is provided in Tables 3 and 4, and time series showing adult returns and estimated egg depositions in the LaHave River above Morgan Falls are provided in Figure 3.

Table 3. Atlantic Salmon assessment information for index rivers in SFAs 20 and 21 during 2015, including angling seasons, conservation egg requirements, fishway count, percent conservation egg requirement attained, and juvenile assessment results.

	St. Mary's River	LaHave River (Above Morgan Falls)
2015 Angling Season	Closed	Closed
Assessment Information	Juvenile Electrofishing Surveys	Juvenile Electrofishing Surveys (above and below Morgan Falls) Smolt Assessment Fishway Count
Conservation Egg Requirement (millions of eggs)	9.56	6.22*
Fishway Count:**		
Small Salmon	NA	160
Large Salmon	NA	19
% Conservation Egg Requirement	**NA**	**7**
Number of Sites Surveyed and Electrofishing Densities (fish/100 m^2):		
Number of Sites	12	9
Age-0 Parr (Fry)	5.4	0.8
Total Age-1 and Older Parr	4.5	7.9

Table Notes:
NA = not applicable
*The conservation egg requirement reported by O'Connell et al. (1997) has been scaled according to the proportion of habitat area above Morgan Falls (i.e., 51%).
**Corrected for observed fallbacks.

Table 4. Estimates of wild-origin Atlantic Salmon smolt abundance (and 95% confidence interval), production per unit area of habitat (smolts/100 m²) and the smolt-to-adult return rates for the Lahave River.

Year	Wild Smolt Estimate	95% Confidence Interval	Production Per Unit Area (smolts/100 m²)	Return Rate (%)	
				1SW	2SW
1996	20,511	19,886 - 21,086	0.79	1.47	0.23
1997	16,550	16,000 - 17,100	0.63	4.33	0.43
1998	15,600	14,675 - 16,600	0.60	2.04	0.34
1999	10,420	9,760 - 11,080	0.40	4.82	0.86
2000	16,300	15,950 - 16,700	0.63	1.16	0.11
2001	15,700	15,230 - 16,070	0.60	2.70	0.59
2002	11,860	11,510 - 12,210	0.46	1.95	0.45
2003	17,845	8,821 - 26,870	0.68	1.75	0.17
2004	20,613	19,613 - 21,513	0.79	1.13	0.33
2005	5,270	4,670 - 5,920	0.20	7.95	0.54
2006	22,971	20,166 - 26,271	0.88	1.48	0.40
2007	24,430	23,000 - 28,460	0.99	2.33	0.16
2008	14,450	13,500 - 15,500	0.55	1.16	0.30
2009	8,644	7,763 - 9,659	0.33	3.47	0.69
2010	16,215	15,160 - 17,270	0.62	1.81	0.19
2011*	NA	NA	NA	NA	NA
2012*	NA	NA	NA	NA	NA
2013	7,159	5,237 - 10,259	0.27	0.60	0.24
2014	29,175	23,367 - 37,419	1.12	0.55	NA
2015	6,664	6,011 - 7,413	0.26	NA	NA

Table Notes
NA = Not Applicable
*Smolt assessments were not conducted on the Lahave River in 2011 and 2012.

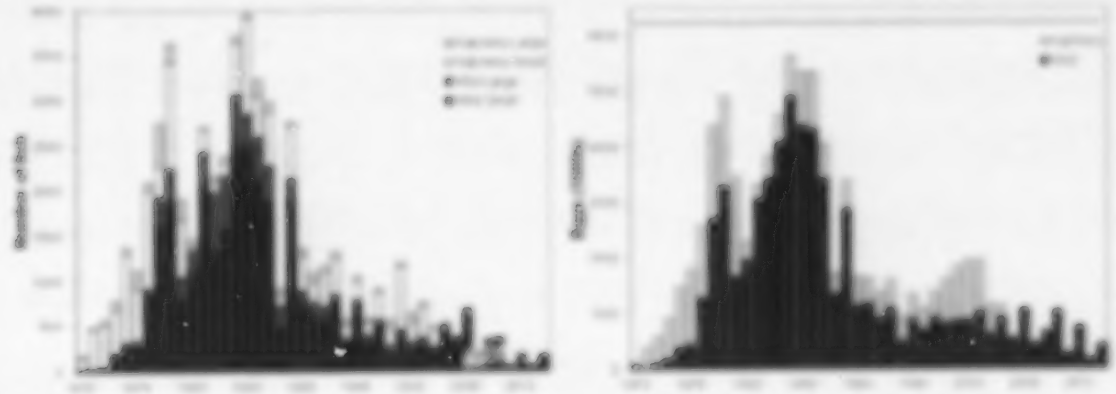


Figure 3. Counts of small and large adult Atlantic Salmon (left panel) and estimated egg deposition (1000's) relative to the conservation egg requirement (right panel) by wild-origin and hatchery-origin salmon at the Morgan Falls fishway on the LaHave River, NS, from 1973 to 2015. The horizontal dashed line in the right panel indicates the conservation egg requirement above Morgan Falls. Hatchery-origin smolts were no longer introduced after 2005.

Outer Bay of Fundy (Outer Portion of SFA 23)

Atlantic Salmon assessment activities led by DFO in the OBoF region are currently focused on two river systems: Saint John River (upriver of Mactaquac Dam, which includes the Tobique tributary) and Nashwaak River (tributary of Saint John River downriver of Mactaquac Dam). The Atlantic Salmon Federation monitors adult and juvenile salmon abundance on the Magaguadavic River. A detailed assessment updating status to 2012 for the OBoF population was completed for the Recovery Potential Assessment of this DU (Jones et al. 2014).

All commercial fisheries for Atlantic Salmon in SFA 23 have been closed since 1984. Low abundance of salmon has resulted in no FSC allocations and no recreational fisheries since 1998. In 2015, all rivers within SFA 23 remained closed to salmon fishing all year.

The Mactaquac Biodiversity Facility (MBF) was constructed to numerically offset the effects of hydroelectric development on salmon in the Saint John River, primarily by producing smolts from sea-run broodstock captured at fish collection facilities at Mactaquac Dam. Based on an agreement within the 'Saint John River Management Advisory Committee' in 2004, the program at the MBF was modified to focus on conserving and restoring a declining resource utilizing captive-reared adults, originally collected from the wild as juveniles, for both broodstock and adult releases for natural spawning upriver of Mactaquac Dam (Jones et al. 2004). About 90 broodstock matings per year are still carried out at MBF for the production of smolts for release downriver of Mactaquac Dam and fall parr for release in the Tobique River.

Egg depositions from spawners in 2015 were estimated to be less than 7% of the conservation egg requirements for each of the three index rivers (Table 5). Captive-reared spawners released upriver of Mactaquac Dam in 2015 potentially increased the estimated egg depositions to 14% of the requirement on that section of the Saint John River. In 2015, fry and total parr (age one and older) densities (Table 5) on the Tobique, Nashwaak and Magaguadavic rivers were also low (<3 fish/100 m^2) and remain well below Elson's norm values. The pre-smolt (Tobique) and smolt (Nashwaak) abundance estimates in 2015 were both less than 0.2 fish/100 m^2 of productive habitat, which is very low in comparison to the reference value of 3.8 smolts/100 m^2 (Symons 1979). Smolt-to-1SW (2.86%) and 2SW (0.45%) return rates for adult returns in 2015

were below long-term means (1998-2014) for the fourth consecutive year (Table 6). A summary of the 2015 assessment results is provided in Tables 5 and 6 and time series showing the status of salmon populations for Saint John (upriver of Mactaquac Dam) and Nashwaak rivers are provided in Figures 4-7.

Table 6. Atlantic Salmon assessment information for index rivers in SFA 23 during 2015, including angling seasons, conservation egg requirements, fishway/fence counts, estimated returns, percentage of conservation egg requirements met, captive-reared adult and juvenile releases, and juvenile and smolt assessment results.

	Saint John River (above Mactaquac Dam)	Nashwaak River (above Durham Bridge)	Miramichi River
Angling Season (2015)	Closed	Closed	Closed
Assessment Information	Fishway Count Juvenile Electrofishing Surveys Pre-smolt Assessment	Counting Fence (Mark Recapture) Juvenile Electrofishing Surveys (above and below Counting Fence) Smolt Assessment (Mark Recapture)	Fishway Count Juvenile Electrofishing Surveys
Conservation Egg Requirement (millions of eggs)	52.50	8.25[a]	1.05
Fishway or Fence Count:			
>63cm Salmon[b]	811	205	7
<63cm Salmon[b]	45	31	3
Kelts / Recaptures / Captures	NA	44 (22 / 19 / 3)	NA
Estimated Returns:			
>63cm Salmon[b]	817	218	7
Proportion Hatchery	0.05	NA	0.14
<63cm Salmon[b]	67	45	3
Proportion Hatchery	0.09	NA	0.00
% Conservation Egg Requirement:			
Without Captive-Reared	8	6	6
Including Captive-Reared	14	NA	NA
Captive-reared Adult Releases	1,213	NA	NA
Juvenile Releases:			
Age-1 Smolt	21,233 (May)	NA	NA
Unfed Fry	552,000 (June)	NA	NA
Age-0 Parr	237,353 (Sept/Oct)	NA	NA
Age-1 Parr	NA	NA	NA
Number of Sites Surveyed and Electrofishing Densities (fish/100 m²):			
Number of Sites	12[c]	10	10
Age-0 Parr (Fry)	2.0[c]	0.4	0.4
Total Age-1 and Older Parr	2.1[c]	2.2	2.8

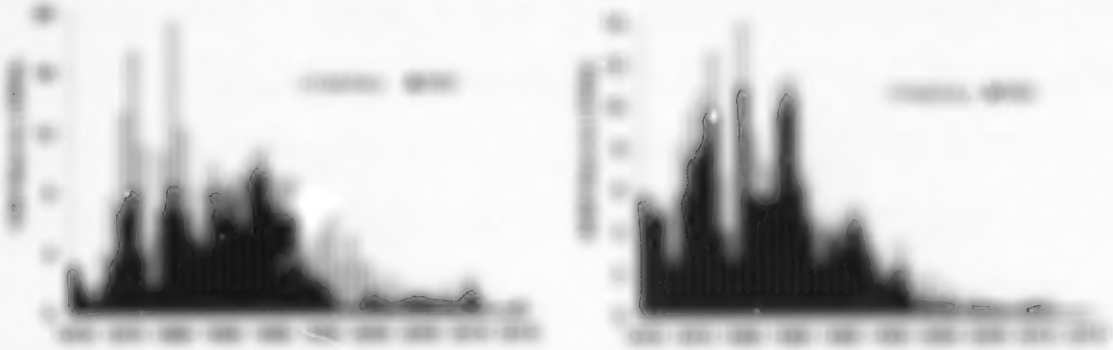
	[illegible]	[illegible]	[illegible]
Wild-origin Pra smolt at Beloit Estimate (5.0 and 95.0 percentiles)	2,000[1,2] (2,000–15,414)	1,000 (1,000–5,000)	Yes
Pra smolt @ Kincott (Rate/100 m²)	2.00[1,2]	2.10	Yes

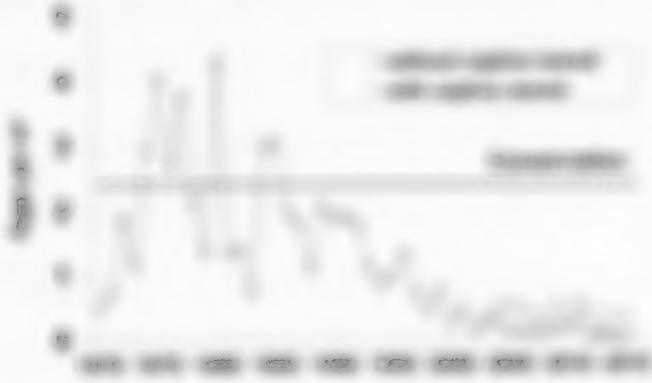
[illegible]
NA – Not Applicable
[1] The current labor cap requirement reported by Marshall et al. (1997) is calculated based on the habitat area above the existing Brown above Dumont Bridge on the Dashnoyak River (i.e., 40%).
[2] One-way order (1997) which will those which return to spawn following a single winter at sea (also termed 1-ocean). Multi-sea-winter (MSW) salmon include those that return after following two or more winters at sea (2+ ocean spawning adults).
[3] Depositioning and pre-smolt results are for the Tarique Pra+ index tributary portion of Manistique Rain.

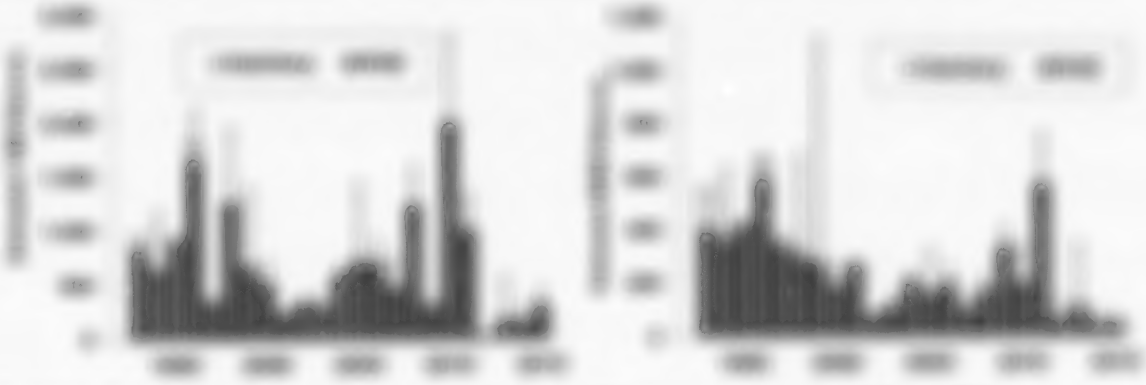
Table 6. Estimates of wild-origin Atlantic Salmon smolt abundance from upriver of Durham Bridge (and 5.0 and 95.0% percentiles), production per unit area of habitat (smolts/100 m²), and life cycle/smolt return rates for the Newfoundland River, 1985–2015.

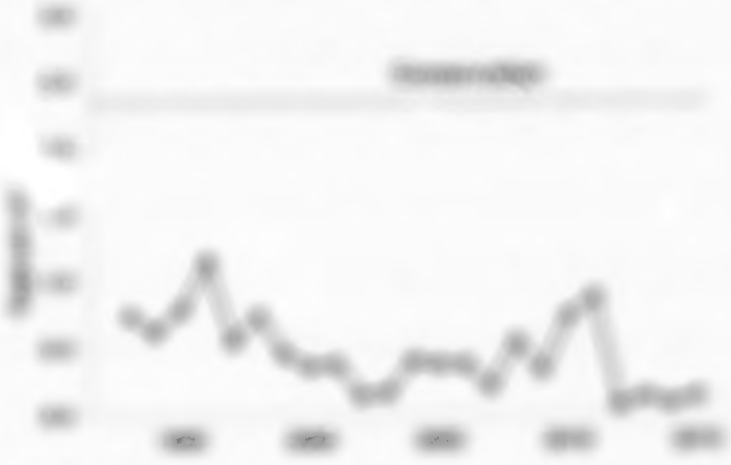
Year	Smolt Estimate			Production (by unit area)	Return Rate (%)	
	Point	5.0%	95.0%		MSW	1SW
1985	22,700	17,400	32,400	2.27	1.21	0.57
1986	26,000	20,100	34,200	2.60	1.76	0.80
1987	15,800	11,900	19,700	1.58	1.01	0.38
1988	11,200	8,100	17,600	1.12	0.71	0.29
1989	14,400	11,200	18,900	1.44	1.01	0.38
1990	9,600	6,800	13,200	0.96	0.58	0.19
1991	13,800	10,900	20,600	1.38	0.91	0.38
1992	7,200	5,200	9,800	0.72	0.43	0.14
1993	28,400	21,600	36,700	2.84	1.61	0.68
1994	21,600	16,900	27,100	2.16	1.30	0.48
1995	7,400	5,600	11,200	0.74	0.48	0.17
1996	16,800	13,100	21,800	1.68	1.14	0.43
1997	12,600	9,800	16,700	1.26	0.86	0.29
1998	8,700	7,100	11,400	0.87	0.61	0.20
1999	11,200	8,700	14,900	1.12	0.79	0.26
2000	14,100	10,900	18,600	1.41	1.01	0.36
2001	11,400	8,900	15,200	1.14	0.82	0.26
2002	7,800	6,100	10,200	0.78	0.56	0.18
2003	9,200	7,200	12,100	0.92	0.67	0.21
2004	6,400	4,900	8,300	0.64	0.46	0.14
2005	10,600	8,300	13,900	1.06	0.78	0.24
2006	8,100	6,300	10,600	0.81	0.59	0.18
2007	5,900	4,600	7,700	0.59	0.43	0.13
2008	7,300	5,700	9,600	0.73	0.54	0.16
2009	9,800	7,700	12,800	0.98	0.73	0.22
2010	12,400	9,700	16,200	1.24	0.93	0.28
2011	8,700	6,800	11,400	0.87	0.65	0.19
2012	11,800	9,200	15,400	1.18	0.88	0.26
2013	10,100	7,900	13,200	1.01	0.76	0.22
2014	7,600	5,900	9,900	0.76	0.57	0.17
2015	9,400	7,300	12,300	0.94	0.71	0.21

[illegible]
NA – Not Applicable









Resources of Uncertainty

There are an agency electrical reports of illegal training activities in a. Settings in violent crimes and poisonings, but they contained contributors of these convictions in the depreciation letters of unavailable to us to create.

The number of small and large options caught and assessed. Training effect, and it went into release mortality within 48 h. A can automated from training a net stock to from the unreferred options hereby. Import stock effect, please can calculated for. Less electrical center, using a a before-after based on the reported option up a a number of the number to electrical station can to maximum progress. For the calibrated option data, under, or over reporting of numbers of options caught and training effect results market assessment results based on a fiscal data. Estimates for 2014 can consolidated to be conditioned, as the time of the assessment, update since training data information, and licence needs can still training electrical. In recent years, after and other estimates

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Sources of Information

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Appendix

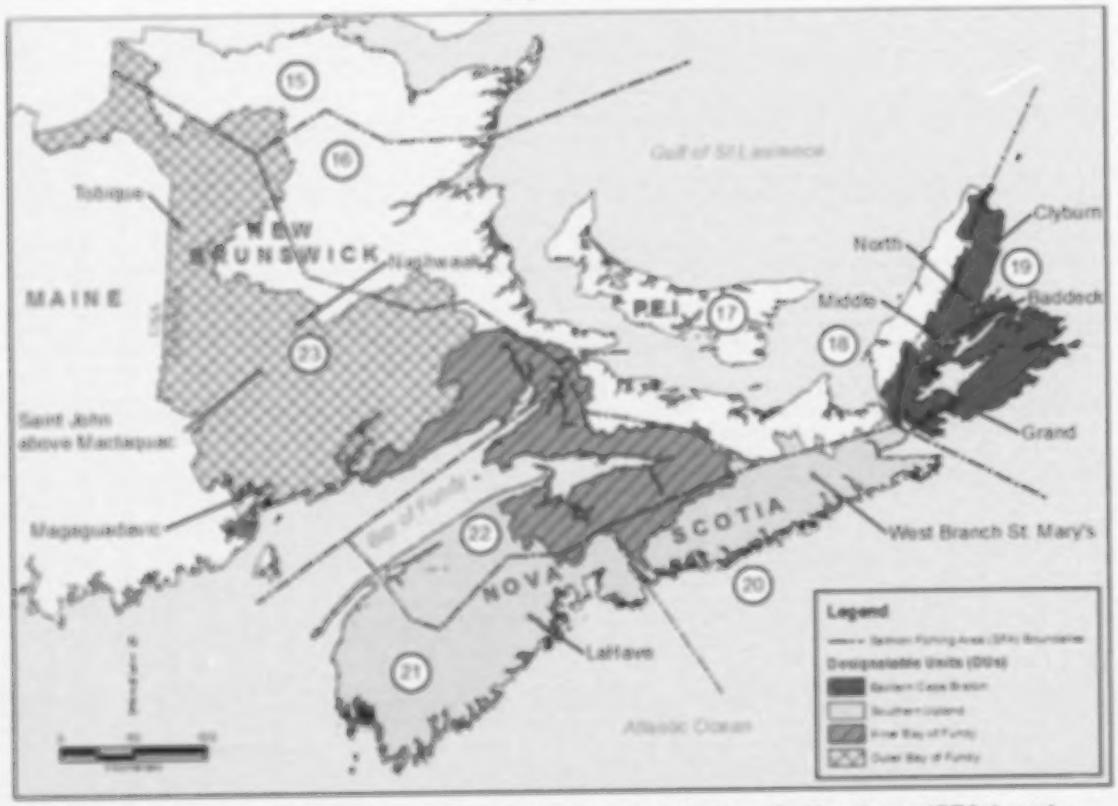

Figure A1. Map showing the locations of Atlantic Salmon rivers, Salmon Fishing Areas (SFAs), and Committee on the Status of Endangered Wildlife in Canada (COSEWIC) Designatable Units (DUs) mentioned in this update. SFA numbers are labeled inside the white circles. Data Source for DUs derived from NS Secondary Watershed Layer (NS Dept. of Environment) and NB Watershed Level 1 Layer (NB Dept. of Natural Resources).

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